57f
8

LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

# SPAWNING GROUNDS OF TUNA AND SKIPJACK

SPECIAL SCIENTIFIC REPORT: FISHERIES No. 18

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

## Explanatory Note

The series embodies results of investigations, usually of restricted scope, intended to aid or direct management or utilization practices and as guides for administrative or legislative action. It is issued in limited quantities for the official use of Federal, State or cooperating agencies and in processed form for economy and to avoid delay in publication.

Washington, D. C.
April 1950

United States Department of the Interior
Oscar L. Chapman, Secretary
Fish and Wildlife Service
Albert M. Day, Director

Special Scientific Report - Fisheries
No. 18

# SPAWNING GROUNDS OF TUNA AND SKIPJACK

Translated from the Japanese language by SCAP translators

Edited by

B. M. Shimada

and

W. G. Van Campen

Pacific Oceanic Fishery Investigations

CONTENTS

| | | Page |
|---|---|---|
| Preface | | |
| 1. | A symposium on the investigation of tuna and skipjack spawning grounds 1/ . . . . . | 1 |
| 2. | A contribution to the study of tuna spawning grounds by Kenzō Ikebe 2/. . . . . | 12 |

1/ From South Sea Science [Kagaku Nanyō] Vol. 4, No. 1, pp. 64-75. July 1941.

2/ [From South Sea Fishery News Nanyō Suisan Jōhō] Vol. 5, No. 4, pp. 9-12 September 2, 1941.

Digitized by the Internet Archive
in 2025

https://archive.org/details/noaa-technical-report-nmfs-ssrf_1950-04_18

## Participants

(December 4, 1940, University Alumni Association Hall)

Ōshima, Masamitsu: Professor, Tōkyō Prefectural Higher School

Kawahara, Shichirō: Chief of the Katsuura Branch, Chiba Prefectural Fisheries Experimental Station

Kawakami, Zenkurō: Nankō Fishing Co., Ltd.

Takatsuki, Shunichi: Professor, Tōkyō University of Literature and Science

Takeda, Shigeo: Japan Tuna and Skipjack Fisheries Association

Okada, Yaichirō: Professor, Tōkyō Higher Normal School

Marukawa, Hisatoshi: Advisor, Marine Chemistry Institute

Amemiya, Ikusaku: Professor, Tokyo Imperial University

Seno, Hidemi: Nippon Women's College

Sumino, Isamu: Nippon Fishing Co., Ltd.

## Sponsors

Hatai, Shinkishi: Director, Palau Tropical Biological Station; Professor Emeritus, Tōhoku Imperial University

Haneda, Yata: Researcher, Palau Tropical Biological Station; Member, Dept. of Medicine, Tōkyō Charity Hospital Medical College

Kanai, Kiyoshi: Councillor, Pacific Society

Takahashi, Keizō: Researcher, Palau Tropical Biological Station; Dept. of Zoology, Tōkyō University of Literature and Science

Niiya, Buei: Dept. of Science, Japan Society for the Promotion of Science

Hirano, Gitarō: Pacific Society

Hatai: I wish to express my deep appreciation to you for sacrificing your valuable time to assemble here. You have already been informed as to the purpose of tonight's meeting so I believe it is unnecessary for me to review it in detail. However, as there are a few persons present tonight who are not acquainted with the objective of this gathering, I would like to say a few words for their benefit.

There exist an extremely large number of marine fish whose spawning grounds have not yet been determined. In fact, I feel I do not exaggerate when I say that almost none have been delineated. Furthermore, nothing has been confirmed with respect to the skipjack and tuna, which are of great economic importance, especially to the Japanese fishing industry. It is to be regretted that so little is known about the spawning grounds, spawning habits, and development of these fish. This difficult problem, however, is not limited to Japan alone - it is universal in nature. In Japan, such persons as the late Kamakichi Kishinouye worked assiduously in collecting skipjack and tuna juveniles. Technician Marukawa, who is present tonight, and others have also been deeply concerned with this problem. They are now conducting a careful investigation but results are as yet unknown. Scientists from various foreign countries have also worked hard on this subject, but despite all this, their situation remains the same as that in Japan in that no conspicuous contributions have been made towards its solution. Due to these circumstances, each Pacific Science Congress usually takes up the question of skipjack and tuna spawning and submits measures to undertake its solution through joint action of various countries. Although many helpful discoveries and studies pertaining to fisheries are reported on at these conferences, held at intervals of three or four years, the problem concerning the spawning habits of skipjack and tuna remains the same as when it was first presented more than ten years ago. No new facts have yet been ascertained.

However, in generalizing on the common efforts and observations of fishermen and ichthyologists, the spawning grounds of skipjack and tuna are, to all appearances, in tropic seas. For example, information such as the capture of skipjack ready to spawn or collection of juveniles believed to be those of skipjack is usually received from the tropics.

Fortunately, our country today has extensive tropical possessions. There is also the Tropical Biological Station sponsored by the Japan Society for the Promotion of Science. It has been my wish for many years to gather various Japanese scientists in an attempt to solve this important problem of spawning, using this Station as a base for operations. The opportunity to realize this desire was made possible through the positive support given by the Pacific Society. I have, therefore, requested the presence here tonight of you authorities on the tropics and those of you who are actually active in the area, to hold a discussion on skipjack and tuna with the main emphasis being placed on spawning. With this symposium as a foundation, I thought we could take up the formulation of a definite plan as to how this undertaking should be started and how it should be effected. Your presence here despite the pressure of other duties is gratifying indeed. Since we do not have too much time, this will serve as an introduction. Now we would like to hear your opinions. I would like first to call upon Mr. Marukawa.

Marukawa: In Japan, research on skipjack and tuna was conducted chiefly by Dr. Kishinouye. Although there are Mr. Kitano's report and a few others in taxonomy, I believe that Dr. Kishinouye was the first to make a scientific study of these fish. The question as to the location of the spawning grounds of skipjack and tuna still is definitely a mystery; I can only conceive it to be in the South Seas. I believe that research soon to begin at the Palau Tropical Biological Station in the South Seas is most ideal. At this point, I will go back into the past for information

concerning the subject. In 1907, I made a tour of about two weeks aboard the Hayabusa Maru of the Fisheries College, which made a hydrobiological survey of fishing grounds centered around Izu Ōshima. At that time, a small fish was obtained from the stomach of a dolphin. This was reported as a young skipjack, but Dr. Kishinouye later stated that the specimen was probably a young frigate-mackerel. Dr. Kishinouye subsequently started to study skipjack young and requested all fisheries experimental stations in the country to forward to him stomach contents of skipjack. Juveniles were caught in larval nets used near the Toshima Islands of Kagoshima. These specimens, said to be most likely the young of skipjack, have already been reported upon by Dr. Kishinouye at the Pan-Pacific Congress. I believe it can be said that no further scientific studies have been conducted on skipjack and tuna since Dr. Kishinouye's work.

I, too, was constantly on the lookout for young fish and had skipjack juveniles recovered from the stomachs of skipjack being processed into dried sticks under the supervision of Mr. Kawakami of the Nankō Fishing Co., Ltd. About 204 specimens have been gathered to date and are reposited with the Fisheries Experimental Station in Tōkyō.

These specimens (shown in figure) were found in skipjack taken at Amami-Ōshima in 1922. About half of these were collected at the Nankō Fishing Co., Ltd. Juveniles of big-eyed tuna measuring 3.5 to 3.6 sun (4.2 to 4.3 inches) were found inside yellowfin tuna taken by longlines in the Tokobei area last year, while I was in Palau, by a ship of the Fisheries Experimental Station. In May, 1934, a report of a large school of blue-fin tuna was received from the Shōyō Maru of the Kagoshima Prefectural Fisheries Experimental Station. Eggs were collected with a plankton net and samples were forwarded to us. These eggs were presumed to be those of tuna and upon examination, were found to be pelagic eggs covered with an oily layer. A large number of blue-fin tuna are caught in the Luzon Straits each year around May. The fishing season is from April to June. When the stomachs of fish caught in May are cut to remove the livers, careful observations of the reproductive organs reveal the ovaries to be of considerable size. The ovaries are extremely well developed in the early part of May, but are said to become smaller between the middle of May and the early part of June together with a loss of weight in the fish. This is based on statements made by members of the Formosa Fisheries Experimental Station. In Wakasa Bay, the gonads are large in June; in the Japan Sea, spawning probably takes place in June. Technician Shimoda of the Ministry of Agriculture and Forestry visited Java, the Sulu Sea, and the Celebes area eight years ago and returned with ovaries of yellowfin tuna from this region. They measured from five to six sun (6 to 7.2 inches) in length and from one and a half to two sun (1.8 to 2.4 inches) in diameter. The fish from which these ovaries were taken were caught in May and June. I thought that the ovaries were fairly well developed and this led me to wonder whether spawning takes place in May or June in the Java, Sulu, and Philippines area. In 1913 and 1914 the Fisheries College conducted an experiment using purse seines to catch tuna near Hahajima in the Bonin Islands. At that time Mr. Kamishirō Kumada squeezed the bellies of tuna caught by the net and obtained eggs. These were placed in a cup for artificial fertilization, but the experiment failed because of the inability to capture a mature male. However, the eggs were retained and brought back. Mr. Kumada's experiment was the only attempt at artificial fertilization of mature eggs. It was decided recently to conduct similar tests under Director Hatai, but I believe that the experiment cannot be carried out without difficulty because of its complexities. I am willing, however, to give all possible assistance to this project. I wanted to go to Palau last year to study the spawning season of skipjack, but I arrived there between November and January so that I was unable to find a mature ovary among those which I examined. I requested Mr. Kawakami to gather data on the length of the fish, the condition and size of the gonads, the number of vertebrae, etc. In addition, I

also requested a record of stomach contents, the size of fish, and daily catch. In looking at a table of measurements, the lengths and weights of skipjack caught by pole and line are small. The smaller ones weighed about 200 momme (1.65 lbs.) and the larger ones, from 300-400 momme (2.4 to 3.3 lbs.). Among the larger ones, there were fish that weighed one kan (8.27 lbs.). The catch in May was extremely large so I thought that skipjack spawn possibly in April and May. Not too many of the larger skipjack were caught by pole and line, and I believe that this is probably due to the fact that as the ovary enlarges, it presses against the internal organs causing a loss in appetite. Furthermore, I believe this to be the solution to the question why the possibilities of catching large mature skipjack decrease during the spawning season. I believe that research would be expanded if nets as well as hooks were used to capture fish. At any rate, it would confirm the fact that ovaries of skipjack are comparatively large from April on, reaching maturity in May. In searching for spawning grounds, juveniles are collected and the sector from which these are abundantly recovered is assumed to be the spawning area. If a thorough investigation were made around Palau, I feel that the problem of skipjack spawning grounds would shortly be solved.

Hatai: Thank you for your information. Next, I shall call upon Mr. Ōshima for discussion.

Ōshima: I am an ichthyologist, but until recently my work has been devoted primarily to research on salmon and trout. I regret to say that my knowledge of skipjack and tuna is very limited outside of the few observations I made in the South Seas when I was formerly in Formosa. At that time Dr. Kishinouye, who was specializing on these fish, had his eyes set on the southern areas as spawning grounds for skipjack and tuna. He requested that we watch for juveniles during our study of other families of fish. At one time we forwarded some specimens to him which were taken off the coast of Keelung, but these were all Scomberoides, more specifically, a species of Chorinemus.

The salmon and the eel stop feeding entirely when they begin their spawning migration. Consequently, eels descending towards the sea are not attracted by bait placed in bamboo baskets set out to capture them. Because of such examples, Mr. Marukawa's statement that skipjack and tuna cannot be caught during the spawning season may be true. The reason why skipjack with matured eggs cannot be caught in May may also originate from such circumstances. However, according to recent reports, skipjack of various sizes are taken throughout the year by the fishery in British North Borneo. Numerous skipjack weighing about 100 momme (.82 lbs.) are caught in the Sulu Sea around November; these constitute a nuisance because they are not of commercial size. About 60% of those skipjack caught in April and May, however, are adults and the roe and testes from these fish are often canned. Mr. Tsuji, the present managing director of the Borneo Fishing Co., Ltd., had these products on hand at the time of my visit and he showed us a sample can containing a large testis. These facts are clearly contradictory to the aforementioned conception that skipjack cannot be caught during the spawning season. It is possible that juvenile and mature skipjack and tuna are not caught in waters adjacent to Japan because this area is not a migratory sector for these particular sizes of fish.

Upon closely correlating the flow of the Kuroshio to the migration of skipjack and tuna, it may be assumed that the originating point of the Kuroshio, where the Northern Equatorial Current touches the Philippine Islands and changes course to the northeast, is the spawning ground for migratory fishes. For example, the Japanese mullet, found frequently along the coast of Formosa, descends southward from the South China coast along the western coast of Formosa, spawns in the Bashi

Channel and returns north. The same species found in Nagasaki Prefecture, from which the noted product of that prefecture, dried mullet-roe, is manufactured, journeys to the Sakishima Islands in Okinawa to spawn in the Kuroshio. Therefore, since skipjack and tuna are fish which inhabit warm waters of constant temperature, I believe it is logical to search for their spawning grounds in areas providing these conditions, namely, in the Celebes Sea, the Sulu Sea, etc. There are, however, localities where small skipjack are caught throughout the year such as in the Senkaku Islands off Miyako. Then there are some areas to which skipjack do not migrate except for certain periods. What these facts suggest is as yet questionable.

I believe the necessity exists for studying whether skipjack and tuna remain in specified localities at any certain period during their development, if coastal schools differ from migratory schools, and if a single large group migrates in the warm waters of the vast Pacific. In order to do this, however, it is important to study by some means the age of fish caught in the various areas. One method is by examining the rings appearing on scales and vertebrae. I feel that the selection of Palau as a principal research point is ideal as skipjack and tuna can be caught there throughout the year and it is near their presumed spawning grounds.

Mr. Takeda, did you visit the Philippines and Borneo areas?

Takeda: I was informed of this meeting by Mr. Marukawa, but now that I am here, I find I have very little to contribute to the discussion. Because I specialize in fishing, I have experimented with fishing techniques but not in biology. With the recent increase in the price of skipjack and tuna livers, the entrails of these fish are being retained. Therefore, I believe the collection of reproductive organs has been simplified.

In 1930, I went to the Sulu Sea between November and December to fish for tuna. Skipjack, however, are abundant in this season. In Japanese waters, the fishing vessel is generally directed to a sighted school of fish, but in the Sulu Sea, skipjack approach the boat. At first, small carangids gather around the buoy tied to the longline and these gather around the stern of the ship after following the longline when it is hauled in. The skipjack strike for the carangids as the vessel proceeds to take in the line. These skipjack, weighing about one kan (8.27 lbs.) were brought back to Japan and their ovaries measured over 1.2 shaku (1.19 ft.) in length [!]. These are presently preserved at the Kochi Prefectural Fisheries Experimental Station. Thereafter, I went to Borneo at the request of Mr. Marukawa to experiment in the artificial fertilization of skipjack. When I arrived there, however, I discovered that the ovaries of skipjack were not as large as described. Ovaries about 5 to 6 sun (6 to 7.2 inches) can be found almost all year round, but I never found many which were ready to extrude mature eggs. Dried skipjack sticks are made of female and male skipjack. It is very difficult to distinguish between males and females by observation. We once thought that fish with large bellies were females, but were surprised to find them males. As a consequence, it is impossible to conduct experiments on artificial fertilization haphazardly aboard skipjack vessels. Actually, we never did conduct this experiment because we couldn't differentiate between a male and female skipjack. I believe that research would gain through study of the egg.

Marukawa: The simplest way to tell between a male and female skipjack is to observe the shape of the tip of the head. Fish with pointed lips when observed from overhead are males and those with rounded lips are females. I don't think that there are any other methods for distinguishing between the two sexes. When fish are observed from posteriorly, those which become narrow from the eyes forward and have sharply pointed lips are males; females are those with somewhat rounded lips.

Previously, when I was aboard the fishing vessel Fukuchi Maru No. 5 from Yaizu, I had the crew arrange skipjack on deck. Those fish with pointed snouts were placed on the starboard side of the bridge and those with rounded snouts were placed on the port side. I declared those fish on the starboard to be males and those on port to be females, and had them opened. There was practically no error in my selection and the fishermen were amazed. I believe that this is a simple method for distinguishing between male and female skipjack.

Takeda: It certainly is convenient to learn of such a method. Among tunas, the most commonly known is the bluefin tuna which visits our waters; relatively less is known of the yellowfin and big-eyed tuna. I have heard that in May and June, the waters between Formosa and Okinawa become black with sperm emitted by blue fin tuna. I was in Shikoku for a long time and I observed fishermen catching skipjack and tuna with well-developed eggs between Iyo and Tosa during the same time of the year. In waters adjacent to the Nicobar Islands off the Malay Peninsula, about 70% of the tuna carry mature eggs between November and March. I was told that the large spawning sizes were caught on long lines. This method limits the propagation of tuna and skipjack so that fishing was restricted to pole and line fishing. I concluded this period to be the spawning season. Skipjack weighing from 200 momme (1.65 lbs.) to 250 momme (2.06 lbs.) are caught near Japan between May and June. Small skipjack such as these can sometimes be caught in Borneo. The smallest fish range from 60 to 70 momme (.5 to .58 lbs.). I believe it is possible to catch even smaller sizes if fishing methods were changed and if fishing were done particularly for this purpose.

Kanai: How many dried skipjack sticks can be obtained from a large skipjack carrying mature eggs?

Takeda: Four sticks can be obtained from the larger fish.

Kanai: Not long ago, I saw what I thought to be a dolphin between the Philippines and Borneo. However, according to the ship's captain, this fish was a large skipjack from which eight instead of four sticks could have been obtained.

Takeda: The large fish are tuna from which eight dried sticks called "renga-bushi" [TN:"brick-sticks"] can be made. What you mistook for a dolphin was probably a tuna. The largest skipjack weigh about 4 kan (33.08 lbs.); those in Borneo, two kan (16.54 lbs.).

Kawakami: A three and a half kan (28.94 lb.) skipjack was once caught at Saipan.

Marukawa: Mr. Kawahara, won't you say something?

Kawahara: We frequently found skipjack with eggs between March and May. However, we did not report on the size of eggs or fish.

It seems that skipjack carry matured eggs regardless of body size. Eggs were never extruded when pressure was applied to the belly of skipjack immediately after capture. We did find, however, ovaries which emitted eggs through light pressure after these were removed from the fish.

We occasionally caught young skipjack up to about 3 sun (3.6 inches) in length. We tried to find juveniles measuring 1 sun (1.2 inches) in length and usually examined the stomachs of skipjack, tuna, and other fish in search of these young skipjack. Fish containing many small specimens were found, but we couldn't tell whether these young fish were skipjack.

If I recall rightly, I believe it was in November, 1931, that I was requested by Mr. Takuo Mimura of the Fisheries College to forward him a large number of skipjack eggs so that he could study these. At that time I was also interested in this subject so I collected the eggs, but I was unable to send Mr. Mimura any of my samples which were left behind when I left the Experimental Station in May of 1932 to return to Japan. From my investigations of the waters around Palau, I believe that the spawning season of skipjack is in March, April and May, but I have no proof. There seems to be no set period which can be referred to as the spawning season in tropic seas where atmospheric and water temperatures are high and do not vary with the season. It is therefore possible that skipjack spawn throughout the year.

At present, I am studying the ecology of skipjack taken at Katsuura in Chiba Prefecture. I occasionally see eggs in the so-called "early" skipjack which are caught in May and June near the Zunan Islands and off the coast of outer Bōshū, but the gonads of these skipjack are generally not well-developed. Each year from about August to October, a great many so-called "descending" skipjack which are much larger than those caught in early summer are taken in coastal waters from Inubō Point to outer Bōshū. Although caught in the same season, the flavor of these fish is far superior to those taken in the Sanriku areas. A large number of "descending" skipjack carry well-developed eggs and ovaries of some fish are reddish in color and slender while others are slightly hard so that it is difficult to tell whether these skipjack have already spawned or whether they are in the process of spawning. Further studies are being continued.

Marukawa: The "descending" skipjack are probably those which have already spawned. It seems that tropical waters such as those around Palau are still the best places from which to gather material.

Hatai: I understand that skipjack in weakened condition are found close to shore from August to September in the Jaluit area and that these fish are hand-caught by the natives. I have also heard that on some occasions the waters teem with these fish.

Marukawa: Mr. Kawakami, I shall now ask you to speak to us on the Palau area.

Kawakami: I spent about four years in Palau, studying the skipjack and tuna. It was recently mentioned that the great amount of skipjack is taken in March and April; I believe that the figures vary with the year. The greatest catch seems to occur from February to July. The schools of skipjack in this area seem to be of three types. During the normal season schools are divided into those with fish weighing about 300 momme (2.48 lbs.), 500-600 momme (4.1-4.9 lbs.), and 1 kan (8.27 lbs.). In April and May, the schools consist largely of very small fish which are believed to migrate south. Observations made between the latter part of March and early April when fishing boats go out continuously, revealed the skipjack catch around Palau to be small at this season. In the Tokobei and Helen areas, however, large schools of skipjack are present and after a half a month or so, the schools tend to increase in the Palau region. Skipjack are first caught in western Palau and a month later the fishery shifts to the eastern coast. The eastern side is leeward of the Equatorial Counter-current and the skipjack remain here for a long time. In September, after the Equatorial Counter-current degenerates, skipjack again tend to shift to the west. Skipjack normally decrease in number during the period between the change from the rainy to dry season which is in July or August. In July and August, an oily type of skipjack called aburagatsuo is found in the catch. The quality of skipjack sticks known as aburabushi is poor. Reproductive organs of skipjack caught in May and June were full, but they appeared to

be slender and thin after July and August. It appears that the skipjack catch in Palau decreases during the seasonal change from February to March or January to February. Spawning of skipjack may be influenced by the weather. In regard to this, it is interesting to examine throughout the year, food ingested by skipjack caught near the reefs. The amount of food taken in by skipjack is less in February-March and August-September than in other parts of the year. I think that skipjack spawn immediately prior to these two periods. Food consists chiefly of sardines which closely resemble anchovies and have only a few scales. These fish are referred to as tarekuchi in Palau. In reference to the statement that skipjack approach the reefs in waters around Palau, bait fishermen once caught skipjack in July or August at depths of 30-40 meters four to five miles west of Malakal Island. I once traveled around the Marshall Islands from July to September, 1935 and heard natives say that using round haul nets, they often catch skipjack from June to July near Mille and Arno atolls. In January, 1938, I personally observed natives removing from 2,000 to 3,000 kan (16,540 to 24,810 lbs.) of skipjack from a "corral" at a depth of about 10 fathoms off the shores of the Sulu and Celebes Seas south of the Philippines. It is apparent that skipjack can be caught within the reefs in a comparatively calm area. This had led me to believe that the selection of such areas would expedite ecological studies of skipjack.

Hatai: Thank you very much. Small skipjack seem to appear near Koror at a certain season.

Marukawa: Mr. Sumino, what is the situation in the Philippines?

Sumino: Skipjack and tuna fishing ceases in August and September in the Philippines because of a shortage of bait and rough weather. Skipjack frequently enter the numerous "corrals" built near Basilan Island off Zamboanga, particularly those on the east side of the island. These fish generally are taken between November and March, and it appears that greater catches are made during spring tides with as many as 15,000 being caught at one time. A site directly in front of a protruding sand bar and eight to ten fathoms deep is most suited for a construction of a "corral", which may serve as a fish-pen. The natives sleep in an improvised hut near the mouth of the "corral" and when a school of skipjack approaches, the natives get into seven or eight canoes called "pintas" and corner the skipjack by beating on the gunwales of their boats. As soon as the skipjack enter the "corral", the entrance is closed by spreading a net.

The offshore fishery is generally poor at this time of the year, so that "corral" fishing, which requires small capital and little labor, is profitable. Offshore fishing, however, commences in April and May, and boats generally come back with good catches. The best fishing grounds are located along the line extending from Sibuco Bay on Zamboanga to Cotabato in central Mindanao. Most of these fishing areas are located in tidal zones. A hardy sardine called tambantoroi approaches the shore and it is thought that the skipjack follow these in. Fish caught during the best season are uniform in size and weigh about 3.2 to 3.5 kg. These are largely skipjack with well-developed eggs. In a normal year fishing is poor in August and September. During this period tuna and skipjack are caught in almost equal proportions, 60% skipjack and 40% tuna. The size of skipjack varies considerably, with the larger ones weighing up to 6 kgs. and the small ones weighing about 1 kg. The majority of these fish carry well-developed gonads and some are about to spawn. Since our firm canned skipjack, we were able to examine skipjack ovaries, but I was not interested in the subject at the time so I regret that I have no information to contribute. At present, almost all the ovaries are being discarded although the Filipinos relish salted skipjack eggs. In general, the ratio of females to males is greater and the females seem to carry eggs throughout the year.

Hatai: The subject seems to be somewhat clearer due to the various enlightening discussions. I wish to call now upon Mr. Amemiya.

Amemiya: I should like to refer to some points which come to mind. Among skipjack, there are those which live in tropic waters where temperatures remain constant throughout the year, and those which frequent the temperate zone. The latter group migrate as far as eastern Hokkaido. Although fishery technologists have probably noticed that the quality of the meat of tropical skipjack and migratory skipjack differ, this should be carefully investigated. It would probably be helpful to consider the problem of skipjack spawning in reference to other fish having identical living habits such as the flying fish.

The skipjack and flying fish are both tropical forms, except in that one group of skipjack migrates in summer. Since the temperature of sea water in the tropics is constant with no seasonal change, what factors determine the spawning season of fish inhabiting these waters? In fact, it yet remains to be confirmed whether a set reproductive period exists. Flying fish spawn in waters adjacent to Japan prior to the rainy season which approaches at the end of spring. Adult flying fish are even seen in October near Kishū. The spawning season of this species is not fixed and fish with well-developed eggs are occasionally seen between these periods. Similar conditions may prevail for skipjack; the spawning season is probably not uniform. A veteran fisherman named Yaichi Tosa, who lives at Isosone on Koniya-shima in Satsunan, says that a number of skipjack with mature eggs are seen there in spring, in summer, and even in October. Towards the end of August skipjack with mature and immature ovaries can be seen at Yamakawa and Makurazaki in southern Kyūshū. It can be inferred from these facts that there is no fixed spawning season for skipjack in the south and that spawning probably extends over the whole year with periods of peak spawning. The Japanese anchovy and the English herring spawn periodically but throughout the year. This tendency is believed to prevail with skipjack. Of course, it does not mean that skipjack spawn independently. The spawning of individuals continues over a long period of time so that when observed in total, it appears that the spawning periods are interlinked. Although the gonads of skipjack inspected at the Misaki Fish Market in the summer of 1940 appeared to be of the same shape, there was a marked variation in development. This indicates that the spawning of skipjack is continuous and that there may be peak spawnings which are not necessarily confined to any definite period. Keitarō Uchida and Yaichi Tosa both state that skipjack do not spawn near the surface but at considerable depths. They say that the eggs probably float to the surface after deposition. Although there is no accurate basis for these statements, there are some points which must be taken into consideration.

The spawning grounds of tuna are definitely not localized but are widespread. The blue fin tuna seems to spawn around July in Toyama Bay in the Japan Sea as schools of adult fish with mature reproductive organs appear in this area. This, however, does not happen every year.

Marukawa: The tunas in Formosa carry extremely large eggs in May.

Okada: The study of the spawning grounds of skipjack is a major problem comparable to the previous study on eels by Schmidt. It appears that the tunas of the Atlantic have been fairly well studied while research concerning those of the Pacific has been neglected. In referring to Mr. Amemiya's statement that flying fish spawn continuously, I feel that this phenomena occurs in localities where there are slight changes in water temperature. For example, the six-pointed sponge which is found at a depth of about 250 fathoms carries eggs throughout the year. The change in water temperature at such a depth is very slight during the year.

The same is true of animals which inhabit waters of high constant temperature. The kawanina, a hot springs form, always carries eggs when found in hot springs, but those at the periphery of the springs have definite egg-carrying periods. The fact that the skipjack and tuna spawn over a long period even though they may have an occasional prolific period is probably related to changes in water temperature. Walford states that tunas spawn at 20- 100 fathoms and that following spawning, the eggs float in the middle stratum of the sea. There may be some tuna which spawn at the surface, as mentioned by Mr. Marukawa, but I believe that in searching for eggs it is necessary to investigate the middle or lower strata. I also believe that it is necessary in connection with a study on spawning habits that the food of large fish other than those which feed on young skipjack should be studied. That tunas frequent deep waters is suggested by the fact that they eat Spirula, a gastropod.

Hatai: I wonder whether the fact that eggs are found throughout the year can be interpreted to mean that the egg is carried in the ovary for a long time. Also, if an oil layer envelops the egg they should float immediately after spawning. What do you think of this?

Amemiya: Such interpretations are possible, but they are still unconfirmed. If one desires to seek small skipjack, I believe he should look for other large fish which prey upon the smaller ones. As Dr. Kishinouye mentioned, it is best to recover juveniles from natural collectors.

Hatai: However, in order to study this problem, wouldn't we have to restrict ourselves to juveniles?

Amemiya: It would be a good idea to collect juveniles by means of a jack-lamp.

Marukawa: The use of a jack-lamp may be a good idea. The Hakuō Maru is collecting small fish in the South Seas by means of a jack-lamp.

Amemiya: It is said that the skin of skipjack becomes coarse after spawning.

Marukawa: It is said that those which have spawned become reddish in color.

Amemiya: There are skipjack which follow those which have been hooked. On one occasion, a swordfish extruding eggs was caught.

Takeda: It seems that other fish accompany the albacore when it is caught.

Hatai: Mr. Takagi, have you anything to say?

Takagi: I am definitely not acquainted with the subject of skipjack and tuna spawning. I am, however, in support of this new program. On the basis of information presented by individuals having practical experience, it seems that mature skipjack are not difficult to catch and that artificial fertilization is a great possibility. Embryological research on skipjack through selection and training of qualified personnel will not only be a great contribution to genetics, but I believe that it will also be basic to the expansion of the fishery. Therefore, I hope that this project will be initiated immediately, whatever the cost.

Hatai: In regard to the question of steps to be taken on the study of skipjack spawning grounds, I will read today's proceedings carefully and will draw up a plan for your comments at the next meeting. We have heard a great deal on the subject matter, but only a very small part is clear so that the problem remains

practically unsolved. It is an extremely complex subject which I want to see solved by the Japanese. This cannot possibly be done through the efforts of one man. I wish to mention here again that I shall rely upon your future cooperation. Since it is late, I suggest we close this discussion for the present. Thank you all for your informative contributions.

According to reports, the Pacific Society has contributed a certain amount of survey expense funds to the Japanese Society for the Promotion of Scientific Research in order to make a study of the spawning grounds of skipjack and tuna, and research on this important and difficult problem is being carried on by the Tropical Biology Experiment Station at Palau. Several years ago, Mr. Keizō Takahashi of the Experiment Station was already conducting research on skipjack spawning grounds. As a result of conducting artificial fertilization on mature skipjack eggs which he collected from Palau waters, he was able to report the verification of the assumption that the skipjack spawning ground is located somewhere in that area.

The Celebes Sea linking the Philippines, Borneo, and Celebes was considered the most promising area of investigation in the solving of this problem. Recently I heard that Dr. Masamitsu Ōshima, who was to be dispatched to that area, was prevented by several circumstances from going into the Outer South Seas area (TN: Celebes Sea area). After arriving in Palau last April, he sailed southward from Palau aboard the Zuihō Maru and conducted a detailed investigation of the sea around Helen Reef, Tobi Island, and Halmahera Island.

The Pan-Pacific Scientific Conference held in Canada the year before last, assumed that the solution to this problem could be found generally in the South Seas area. Since then, the fact that investigation and study of the matter have been encouraged steadily in Japan has provoked great interest among our circle, which has some connection with the matter. We must not be indifferent.

The work of discovering the skipjack and tuna spawning grounds, which is the most difficult problem of world fishery science, cannot be accomplished overnight. With all due respect for the efforts of these researchers, we must do everything in our power to supply data relative to this subject.

At present, data obtained from tuna surveys are forwarded from the scene of operations to the Tropical Biology Experiment Station as the occasion arises and are being used to aid in their research.

I hope that this material will aid in furthering the investigation and research and that the research will be completed in the near future. The day of completion will mark a new era in world fishery science.

In our survey of tuna fishing grounds, the catch is immediately eviscerated and thrown into the fish hold. Thus we have many opportunities for observing the roe of the female fish. From our past experience it seems that we have come in contact with a number of tuna with considerably matured roe in various areas around the islands.

It would perhaps be hasty to conclude that the spawning ground of the migratory fishes such as skipjack and tuna, whose range of movement is wide, is necessarily to be found wherever there are mature fish with mature eggs, but we can surely think that the spawning grounds are not far from the place these mature fish inhabit. If this is so, then we can conclude that the spawning grounds are not necessarily limited to the Sulu Sea or the Celebes Sea, but that they can also be found in the seas around the South Sea Islands.

Furthermore, young (immature) tuna are sometimes caught on the tuna longlines during tuna fishing ground surveys. From past experience (though the experiences are few) these young tuna are seldom caught in deep water; they are generally caught near an island (land). Since these young tuna, whose migratory power is comparatively weaker than that of the mature tuna, are caught near islands, we can assume that the spawning ground of their species is found near islands. It is recorded, also, that a few young yellowfin (immature yellowfin) were caught by tuna longlines during the survey conducted by the Zuihō Maru.

In observing the above record, we cannot disregard the fact that the young tuna were all caught in waters close to islands. It is regrettable that the length measurements of the tuna were omitted in 9 to 20. Hereafter, we will do our best to take accurate body measurements of these immature fish and to collect material regarding this phase.

If this material is of any use as reference, it would be an unexpected good fortune. I hope that you researchers will give me your frank opinion regarding this manuscript. (June 10, 1941)

| No | Date of Catch | Position of Fishing Ground | Body Length (cm) | Body Weight (Kan) | Probable Age | Remark |
|---|---|---|---|---|---|---|
| | | 19° 04' N | | | | |
| 1 | 5/28/40 | 145° 48' E | 55 | 0.390 | 2-3 | Near Agrihan |
| 2 | " | " | 56 | 0.950 | 2-3 | Island in the |
| 3 | " | " | 59 | 1.020 | 2-3 | Marianas |
| 4 | " | " | 51 | 0.730 | 2 | |
| 5 | " | " | 69 | 1.700 | 3 | |
| | | 5° 48.5' N | | | | |
| 6 | 12/14/40 | 169° 40' E | 82 | 2.800 | 4 | Near Jaluit |
| | | 0° 12' N | | | | |
| 7 | 5/14/41 | 131° 44' E | 50 | 1.200 | 2-3 | Waigeo I., New |
| 8 | " | " | 50 | 1.200 | 2-3 | Guinea |
| | | 1° 11' N | | | | |
| 9 | 5/15/41 | 131° 50' E | -- | 1.500 | -- | Near Helen Reef |
| 10 | " | " | -- | 1.200 | -- | and Tobi Island |
| 11 | " | " | -- | 1.200 | -- | |
| 12 | " | " | -- | 1.200 | -- | |
| 13 | " | " | -- | 1.000 | -- | |
| 14 | " | " | -- | 1.000 | -- | |
| 15 | " | " | -- | 1.000 | -- | |
| 16 | " | " | -- | 1.600 | -- | |
| 17 | " | " | -- | 1.700 | -- | |
| 18 | " | " | -- | 1.900 | -- | |
| 19 | " | " | -- | 1.400 | -- | |
| 20 | " | " | -- | 1.500 | -- | |

1 Kan : 8.27 lbs.